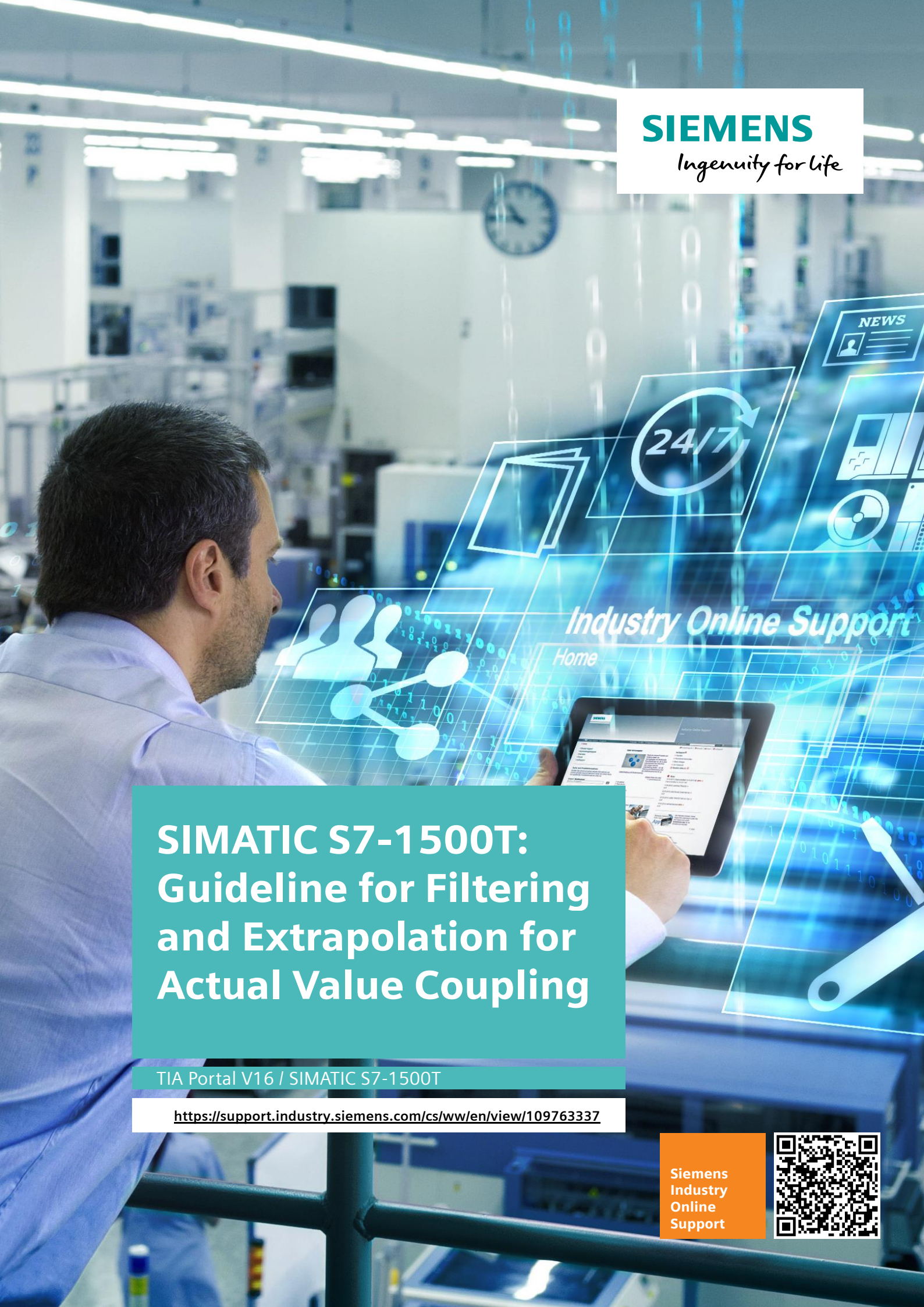


SIMATIC S7-1500T: Guideline for Filtering and Extrapolation for Actual Value Coupling

TIA Portal V16 / SIMATIC S7-1500T

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1 Introduction

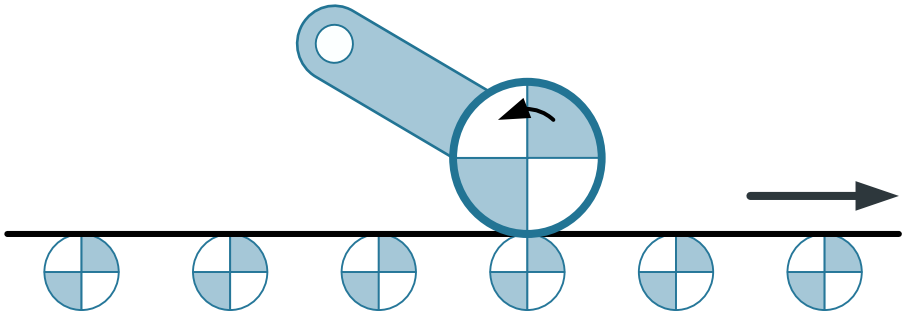
1.1 Leading Value Coupling via Actual Value

The setpoint value of a leading axis is often taken for a leading value coupling, because this gives a smoother course and for this reason is better suited for a leading value coupling.

For applications where a setpoint coupling is not possible, for example, when using an external encoder, the coupling has to be made via the actual position value of the leading axis.

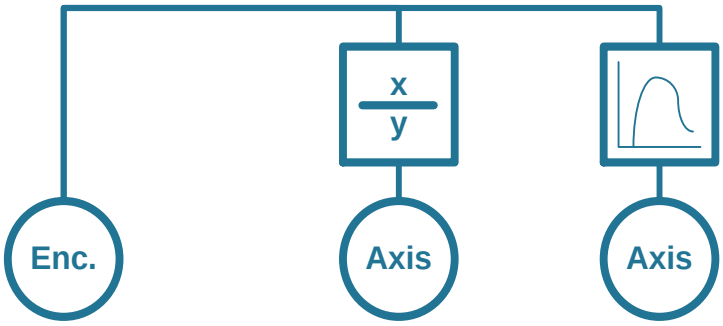
In this document, we take the external encoder as an example, because this is by far the most frequent application.

Figure 1-1 External encoder for acquiring the actual position values



The actual position value of the real axis or the external encoder is provided as the leading axis position of the coupled following axis in the case of an actual value coupling. Here a relative or absolute (position-related) coupling via a predefined ratio can be used, or the absolute (position-related) coupling via a cam.

Figure 1-2 External encoder as leading value for position- and cam-controlled axis



In the case of the actual value coupling, delays occur through acquisition of the actual value, processing in the controller and distribution to the following axes. To compensate these delays the actual value is extrapolated on the leading value side. This means that the leading value is precalculated based on the already known values. In this way the delay-related positional deviations are compensated.

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Notes

In the course of this documentation we show the example of the external encoder as the most frequent case of an actual value coupling. All the information given here about the actual value coupling or the setting of the actual value filtering can also be applied to the actual values of a technology object of a real axis.

1.2 The "External Encoder" Technology Object

In the SIMATIC S7-1500, an external encoder can be created as a technology object in the CPU and used in the user program.

Figure 1-3 Basic parameters of the "External encoder" technology object

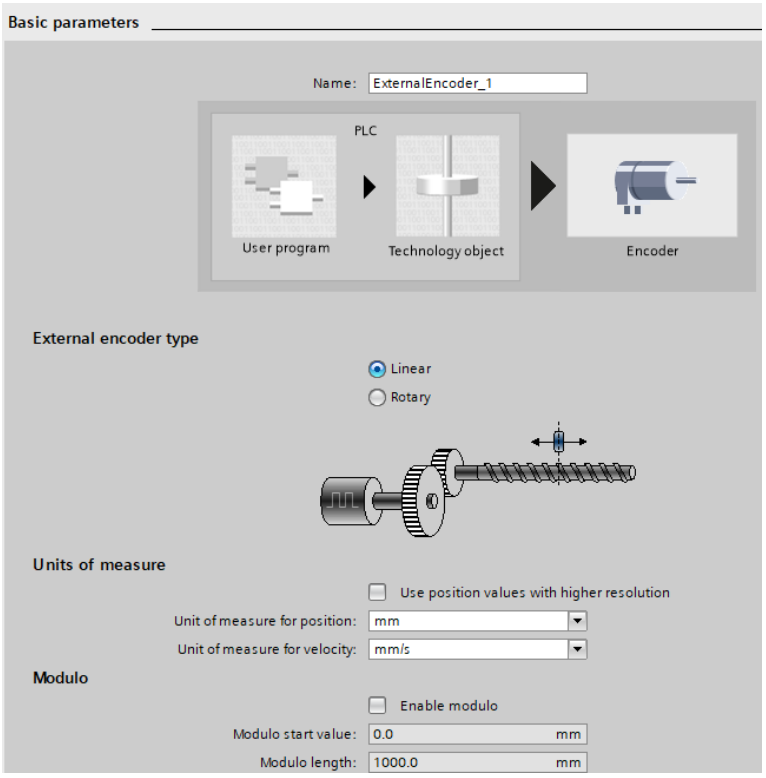
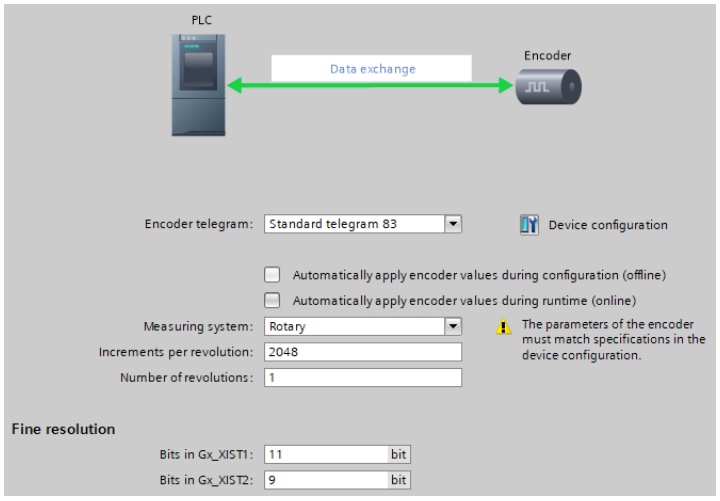


Figure 1-4 Transmission of the encoder position data to the CPU



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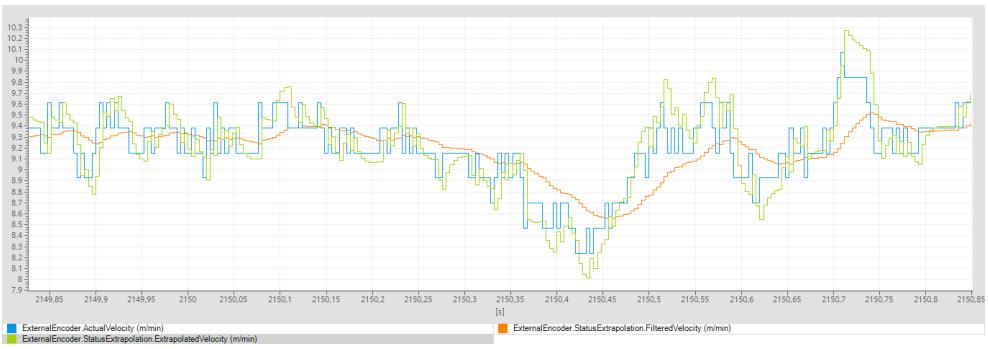
Notes The actual value coupling via the technology object "External encoder" is only available in a SIMATIC S7-1500T.

1.3 Property of the Position Value of the Encoder

Although the external encoder appears to be very even and cleanly follows the material belt or product movements, the signal of the acquired position values might be very noisy. This is particularly noticeable in the actual velocity value derived from the actual position value.

In the following trace recording you see the signal of the actual velocity value of a noisy external encoder.

Figure 1-5 Trace recording of the actual velocity signals



If this very noisy signal of the encoder is taken as the leading value for a following axis without filtering, the coupled axis follows the oscillations of the input signal and the velocity jumps that might result from this. The uneven leading value can therefore be seen and heard on the following axis.

Note When using extrapolation, the leading value deviations caused by the runtime are in fact compensated but the uneven leading value signal deteriorates even more. The extrapolation should therefore only be used when required by the application.

The technology object in the SIMATIC S7-1500T has adjustable filters to smooth the actual position value of the external encoder. This document explains the setting of the parameters available for this.

1.4 Validity

The descriptions and trace recordings in this document have been made using the TIA Portal V16.

The guide can be applied to TIA Portal versions 16 and higher.

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1.5 Changes as of TIA Portal V16

The actual value extrapolation has been extended in Motion Control Version 5.0:

- the extrapolation time conditional on the leading axis can optionally be made ineffective
- the filter time constants of the position filter are directly transferred to the leading axis-related extrapolation time when they are changed
- the filtered actual velocity can optionally be used as the reference velocity
- the velocity filter is extended to a PT2 filter
- the time set in <TO>.DistributedSynchronousOperation.LocalLeadingValueDelayTime for compensation of the delay time for Cross-PLC synchronous operation is included in the extrapolation time as additive time.

Notes The behavior in Motion Control versions < 5.0 has not been changed. When upgrading to version 5.0, the technology objects retain their original functionality.

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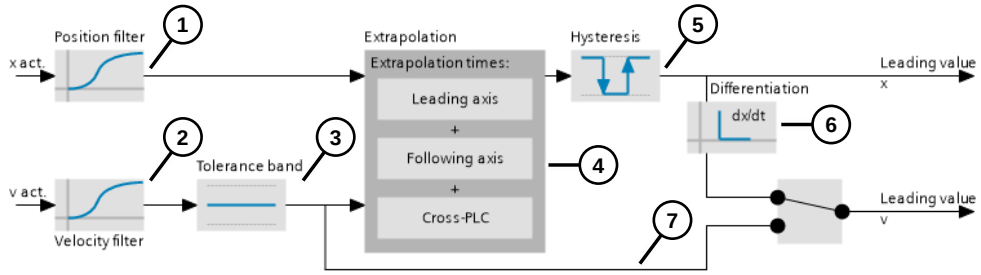
2 Setting Parameters on the Technology Object

2.1 Filter and Extrapolation Parameters of the TO

2.1.1 Available Parameters

The following setting parameters are available in the "External encoder" technology object of the SIMATIC CPU for smoothing and adjusting the position and actual velocity values of the external encoder:

Figure 2-1 Setting parameters of the actual value extrapolation



(1) PT2 filter for the position value of the external encoder
(2) PT2 filter for the calculated velocity of the external encoder
(3) Band-stop filter for the calculated velocity value
(4) Actual value extrapolation
(5) Hysteresis for the actual value extrapolation
(6) Leading value speed via differentiation of the extrapolated position value
(7) Leading value speed after velocity filter and tolerance band

A detailed description of the parameters and their mode of operation can be found in Section 2.2.3.

2.1.2 Rules of Thumb for Setting the Parameters

The following rules of thumb should be applied when setting the parameters.

- **Set the parameters as low as possible.**
  Each parameter setting directly affects the available signal for the actual position value or actual velocity value on the technology object "External encoder". The parameter values should be as low as possible to reduce the effect on the signals, but high enough to obtain an optimum signal trace.
- **Only use extrapolation if absolutely necessary.**
  Usually, using extrapolation significantly deteriorates the position signal that has been smoothed by filtering. So, before using extrapolation, you should check whether your application really needs exact assignment of the actual position values, or whether a slight offset of the position can be tolerated. For example, a running product can be crosscut exactly even with a slight offset of the leading value (e.g. flying saw – cut to length). On the other hand, if

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attention must be paid to print marks or patterns on the product the offset to the leading value must be very low (e.g. flying saw – cut at cutting mark).

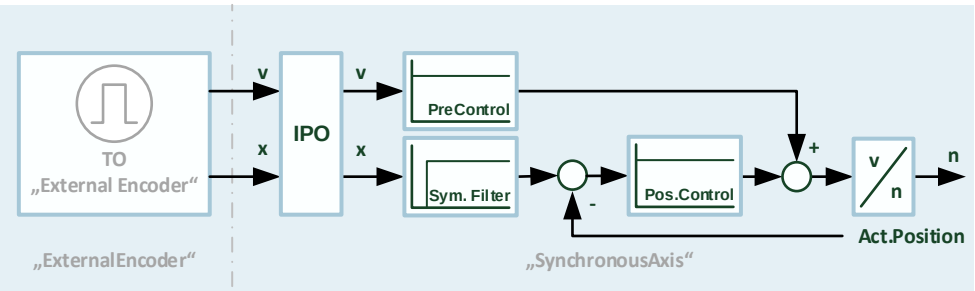
WARNING	**Machine damage through parameter changes during runtime!** If during empirical determination of the parameter values during runtime of the controller you change the values online in steps that are too large, this can lead to machine damage.

2.2 Explanations of the Parameters

2.2.1 Block Diagram of the Coupling to the Following Axis

The technology object "External encoder" is coupled as follows as leading axis for a following axis of the technology object "Synchronous Axis":

Figure 2-2 Block diagram of the coupling to a following axis



The setpoints required for the synchronized coupling for the following axis are formed via the interpolator (IPO).

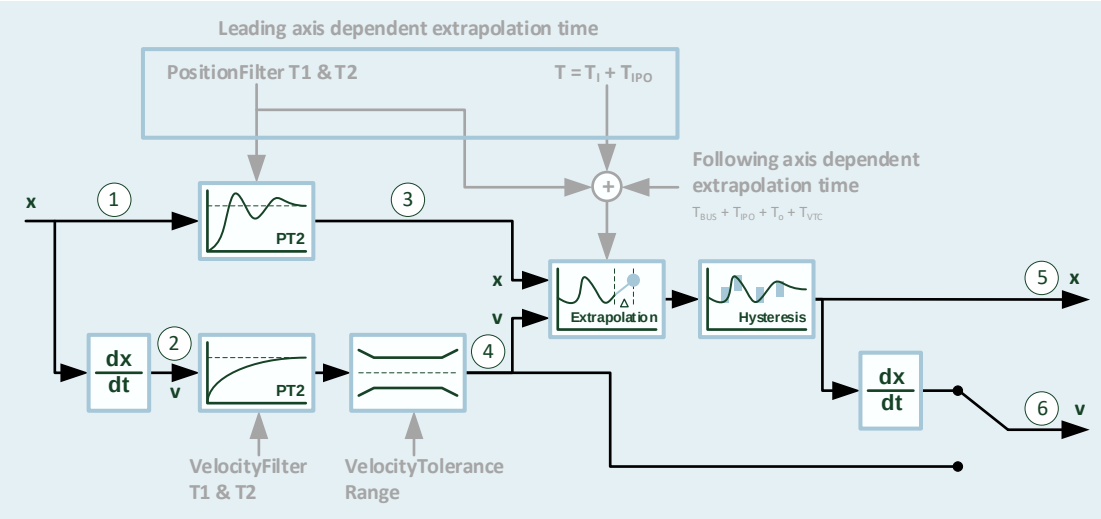
2.2.2 Actual Value Processing of the Leading Value

The following block diagram shows the internal data processing of the leading value taking the example of the technology object "External encoder". The principle shown also applies for the leading value of a real axis.

The external encoder or the measuring wheel delivers the position value x to the technology object. This position value is then processed in the technology object, as shown here, until at the end a position value *x* and velocity value *v* can be made available to other technology objects in the SIMATIC CPU, for example for synchronization applications.

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Figure 2-3 Block diagram of the technology object "External encoder"



Signals in Figure 2-3:

(1) <LeadingAxis>.ActualPosition
Actual position value of the leading axis

(2) <LeadingAxis>.ActualVelocity
Actual velocity value of the leading axis

(3) <LeadingAxis>.StatusExtrapolation.FilteredPosition
Position according to position filter

(4) <LeadingAxis>.StatusExtrapolation.FilteredVelocity
Velocity in accordance with velocity filter and tolerance band

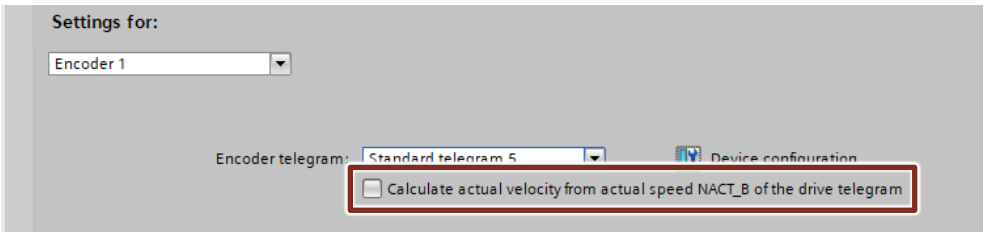
(5) <LeadingAxis>.StatusExtrapolation.ExtrapolatedPosition
Extrapolated position

(6) <LeadingAxis>.StatusExtrapolation.ExtrapolatedVelocity
Extrapolated velocity

The actual velocity value is relevant for extrapolation and leading value velocity. From Motion Control Version 6.0 (TIA Portal V17), it is possible to select whether the actual velocity value of the encoder is calculated by the technology object as before via differentiation of the actual position value, or is derived directly from the value supplied in the encoder telegram or in the axis telegram (NIST_B).

In the case of encoders with a low resolution, the actual velocity value is formed much better in the encoder module (e.g. TM_PosInput) by means of incremental change over time than in the controller by forming the difference from the positions to the cycle limits.

Figure 2-4 Calculation of the actual velocity value from NIST_B



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2.2.3 Effective Ranges of the Parameters

The adjustable parameters of the filter and the actual value extrapolation are arranged as follows in the mask of the technology object and affect the output values as described in the following.

Figure 2-5 Parameters of the filter and the actual value extrapolation

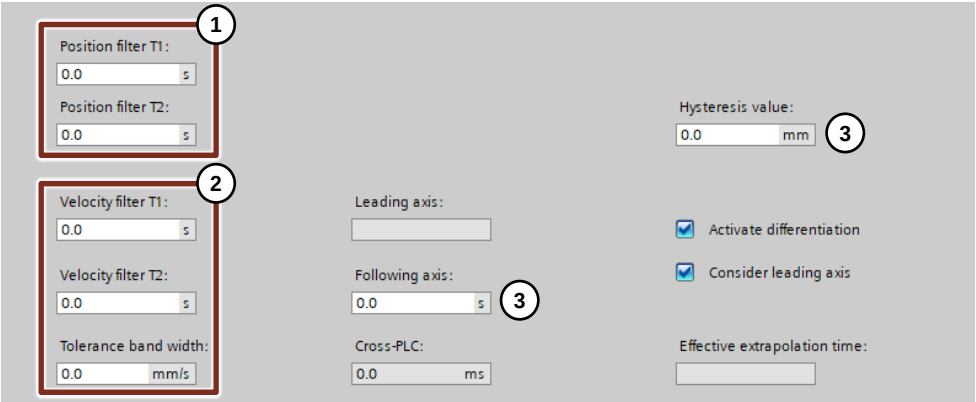


Table 2-1 Filter and extrapolation parameters

No.	Function
1	**PT2 filter for the position value** Using this filter you can smooth the actual position values of the technology object "External encoder". Through the input filter times the actual position value prepared on the technology object is output with an additional delay. This means that by using the filter the real position no longer exactly matches the output position leading value of the technology object "External encoder". The delay resulting from this can be compensated by using extrapolation.
2	**PT2 filter for the calculated velocity** The velocity output on the technology object "External encoder" is calculated in the technology object through differentiation of the actual position values of the encoder. If the value of the actual velocity value of the encoder is noisy, you can use this filter to smooth actual velocity value output on the technology object. Here too it holds that the input filter time causes a delay of the output velocity value. **Tolerance band for the velocity** If the actual velocity is within a tolerance band, the mean value of the bandwidth is always output as the velocity value. In this way fluctuations are tolerated to a certain degree and not output on the leading value. Further information on how the tolerance band filter works is given in section 2.2.4.
3	**Actual value extrapolation** Using extrapolation you can practically do a precalculation of the actual value of the technology object delayed through the filtering and signal acquisition. For this the technology object uses the current velocity of the encoder to calculate the position value and using the specified extrapolation time determines the presumed position of the encoder. The delayed filtered position values of the encoder are therefore shifted forward in time so that they are once again in line with the times of the actual values of other technology objects. However, the extrapolation can also lead to deterioration of the leading values of the following axis. Therefore you should only use extrapolation when the application requires it, in the case of absolute synchronization like flying saw with cutting at cutting mark, for example.

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No.	Function
	Hysteresis Via hysteresis you can, similarly to the tolerance band filter for the velocity, specify a range within which fluctuations of the extrapolated actual position value are not forwarded by the technology object. The actual position values of the technology object are kept constant within the hysteresis. A reversal of direction of the actual position value of the leading axis should be prevented by using a hysteresis, especially when synchronizing the following axis.

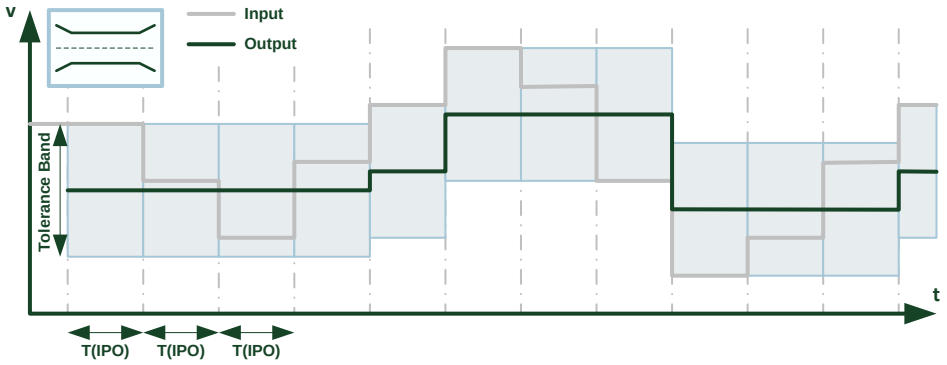
2.2.4 How the Tolerance Band Filter Works

The tolerance band filter is used to smooth the filtered velocity signal of the external encoder.

The tolerance band with the defined width is created in sections of the IPO cycle clock via the filtered velocity signal. If the velocity signal is within the tolerance band, the mean value of the tolerance band is always output as the velocity value.

If the tolerance band is violated upwards or downwards by the velocity signal, the tolerance band is shifted once again towards the velocity signal in the upper and lower limits. In this way the output mean value is also changed accordingly.

Figure 2-6 How the tolerance band filter works



As the figure shows, the tolerance band leads to strong smoothing of the filtered velocity signal. However, in order to keep the deviations of the real velocity signal in a tolerable range, the chosen tolerance band of the filter should not be too large. A guide value here can be the fluctuation amplitude of the filtered velocity signal in the desired working point.

2.2.5 Calculation of Effective Extrapolation Time

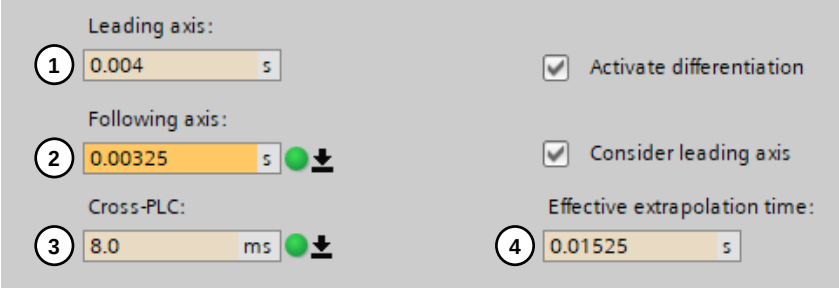
The time delays caused by filtering the actual values are:

1. Leading axis-dependent part
2. Following axis-dependent part
3. Additive extrapolation time for Cross-PLC synchronous operation (delay time due leading value delay)

The total effective delay is displayed in "Effective extrapolation time" (4). The changes to the parameters and the resulting delays are thereby directly replicable.

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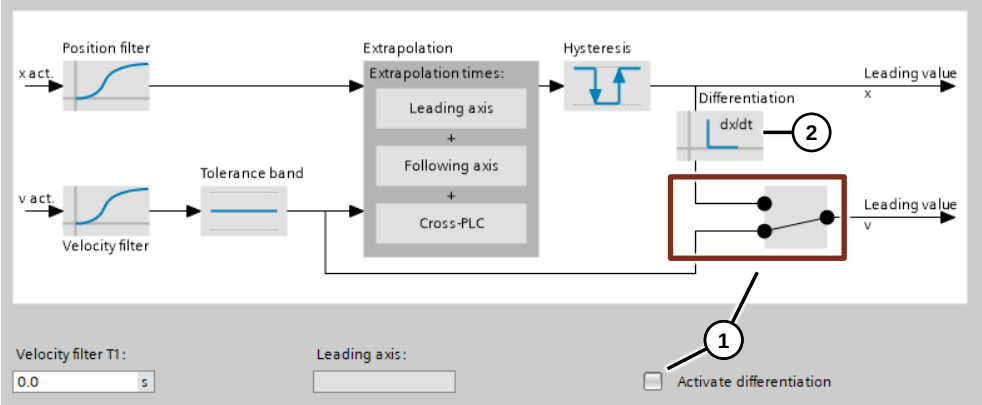
Figure 2-7 Display of delay times



2.2.6 Using the Filtered Actual Velocity Value as the Leading Velocity

The velocity after the velocity filter and the tolerance band for the velocity (1) can optionally be used directly as the reference velocity after extrapolation. The leading value velocity is then not determined via differentiation (2) of the extrapolated position values.

Figure 2-8 Using filtered actual velocity as master velocity



The setting for the velocity used is stored in the variable <TO>.Extrapolation.Settings.ExtrapolatedVelocityMode. Valid values are:

- 0 = FilteredVelocity
  Leading value velocity is the filtered velocity
- 1 = VelocityByDifferentiation
  Leading value velocity is formed via differentiation from the leading value position

Notes

The velocity from the differentiation (mode 1) of the extrapolated position should be used as the leading velocity.

The filtered velocity as the leading valuev elocity (mode 0) will result in a smoother operation of the following axis but if there are high dynamic changes of the leading value the position values of the following axis can briefly differ.

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2.2.7 Deactivating Actual Value Extrapolation on the Leading Axis-Side

The leading axis-side leading axis extrapolation can be deactivated in the settings or with the variable <TO>.Extrapolation.Settings.SystemDefinedExtrapolation = 0. The subsequent extrapolation remains effective independently of this and can be set to the value 0 if necessary.

Figure 2-9 Deactivating leading axis-side actual value extrapolation



2.3 Principle of Extrapolation

The filtering of the actual values of the external encoder causes time delays:

- **Filtered position of the encoder**
  Due to the filtering, a time delay occurs at the current position of the encoder, resulting in a position value that lags behind the actual encoder position.
- **Filtered speed of the encoder**
  Similarly, a delay occurs when filtering the velocity, resulting in a lagging velocity value here as well.
- **Delay from Cross-PLC synchronous operation**
  The delay due to the distribution is also included in the extrapolation time.

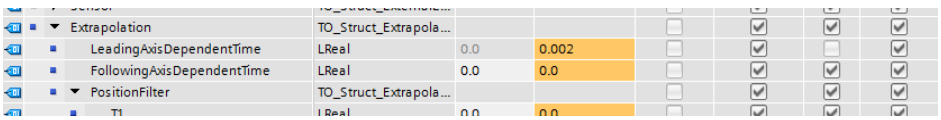
By means of the extrapolation, the delay can be compensated at the filtered actual values.

The extrapolation time determines how far the delayed actual values of the external encoder are shifted in time. The extrapolation time is multiplied by the filtered velocity at the current time and added to the filtered position of the encoder.

In synchronism with actual value coupling, the actual position value of the following axis should behave in accordance with the coupling to the actual position value of the leading axis (position of the external encoder). Time delays occur during processing, e.g., due to the actual value logging at the leading axis, the actual value preparation and filtering, calculation of the synchronous setpoint, and output to the drive up to the actual value at the following axis. These time delays can be compensated for by extrapolating the master value. This means that the leading valueis predicted on the basis of the already known values. This allows the time deviations of the actual value to be compensated for at constant speed or constant acceleration.

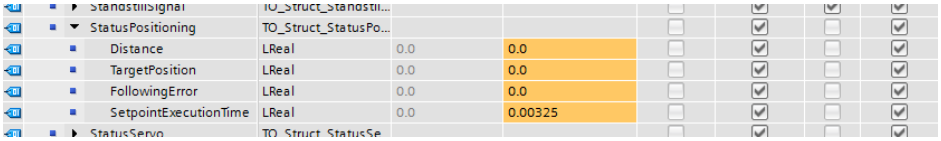
The delays are calculated automatically by the system:

- **Leading axis-dependent part**
  This value is used to calculate the signal propagation time from the encoder to the controller and is automatically applied by the system as an extrapolation time component to obtain the actual position value in real time. This time is displayed at the leading axis in the variable <TO>.Extrapolation.LeadingAxisDependentTime.

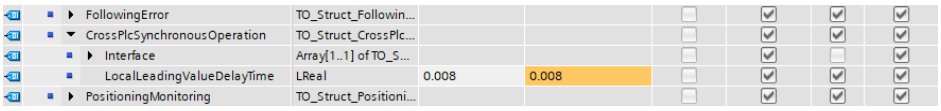


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- **Following axis-dependent part**
  The following axis-dependent part is calculated automatically and displayed at the following axis in the variable <TO>.StatusPositioning.SetpointExecutionTime of the technology object.



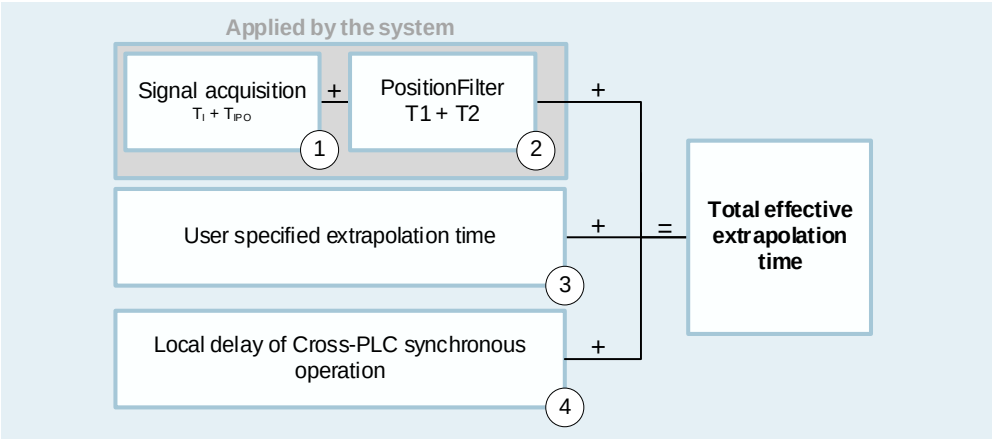
- **Additive Extrapolation Time for Cross-PLC synchronous operation**
  The delay time is equal to the delay time of the local leading value and is set in the variable TO>.DistributedSynchronousOperation.LocalLeadingValueDelayTime. It is irrelevant for this communication time whether a setpoint or actual value is transmitted. The additive extrapolation time is functionally analogous and equal to the delay time of the local leading value.



The following axis-dependent part is an extrapolation time recommended by the system to compensate for delays caused by signal run, bus, and filter times. If this time (unchanged or offset with user-specific times) is entered in the filter parameter screen as a following axis-dependent part, the current position of the external encoder should now match the actual position in real time.

The total effective extrapolation time is, therefore, composed as shown in Figure 2-10.

Figure 2-10 Calculation of the total effective extrapolation time



Signals in Figure 2-10:

(1) <TO>.Extrapolation.LeadingAxisDependentTime

(2) <TO>.Extrapolation.PositionFilter.T1 & T2

(3) <TO>.Extrapolation.FollowingAxisDependentTime

(4) <TO>.DistributedSynchronousOperation.LocalLeadingValueDelayTime

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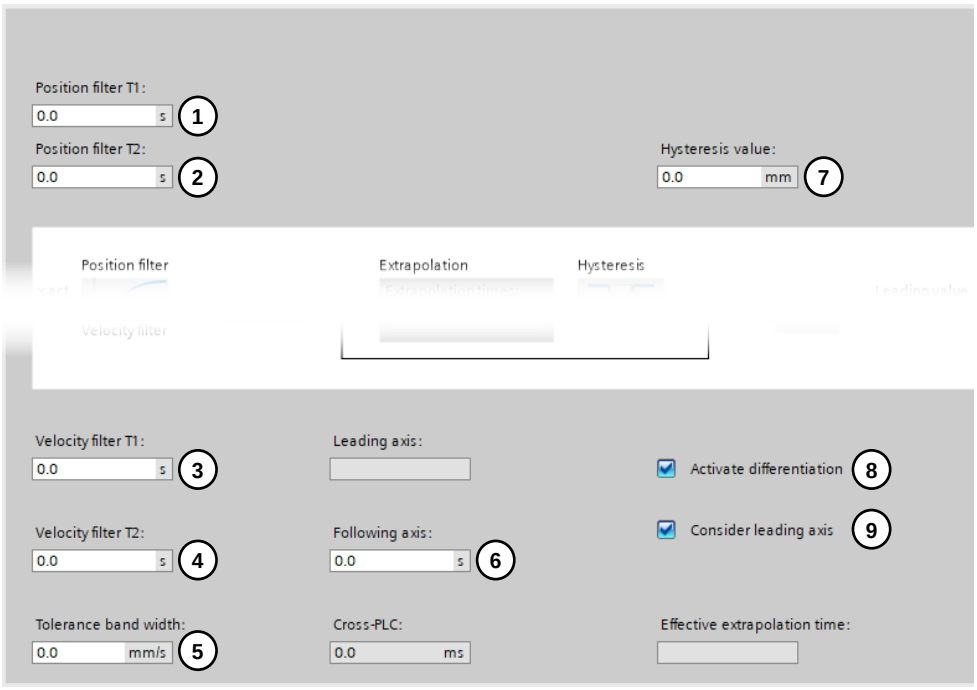
3 Guidelines for Setting the Parameters

3.1 Preparing the Controller

3.1.1 Resetting the Filter Settings in the TIA Project

To be on the safe side you should note existing settings on the technology object "External encoder" and reset all the parameter values of the filter settings of the technology object to the value 0.0.

Figure 3-1 Resetting filter settings in the TIA Portal



Check the active values:
You can check the active values on the technology object via the online view of the technology DB of the technology object "External encoder". Check the following parameter values:

(1) <TO>.Extrapolation.PositionFilter.T1

(2) <TO>.Extrapolation.PositionFilter.T2

(3) <TO>.Extrapolation.VelocityFilter.T1

(4) <TO>.Extrapolation.VelocityFilter.T2

(5) <TO>.Extrapolation.VelocityTolerance.Range

(6) <TO>.Extrapolation.FollowingAxisDependentTime

(7) <TO>.Extrapolation.Hysteresis.Value

(8) <TO>.Extrapolation.Settings.ExtrapolatedVelocityMode

(9) <TO>.Extrapolation.Settings.SystemDefinedExtrapolation

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3.1.2 Loading the TIA Project into the Controller

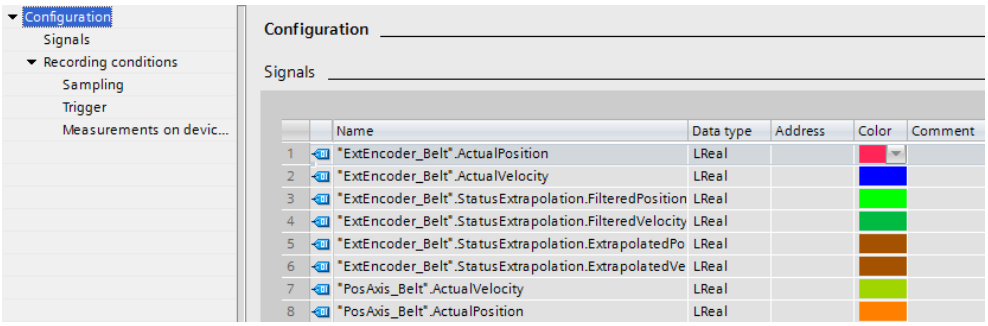
Compile the technology object "External encoder" and load it into the controller.

3.1.3 Preparing a Trace for Signal Checking

To check the input filter settings you prepare a trace recording with the following signals:

- <TO ExtEncoder>.ActualPosition
  Actual position values of the external encoder in the technology object. This signal shows the input signal of the technology object and serves as a reference for the smoothing and delay caused by filtering.
- <TO ExtEncoder>.ActualVelocity
  Actual velocity value of the external encoder in the technology object. This signal shows the input signal of the technology object and serves as a reference for the smoothing and delay caused by filtering.
- <TO ExtEncoder>.StatusExtrapolation.FilteredPosition
  Position of the external encoder after the PT2 filter for the position value.
- <TO ExtEncoder>.StatusExtrapolation.FilteredVelocity
  Velocity of the external encoder after the PT1 filter for the calculated velocity and the tolerance band.
- <TO ExtEncoder>.StatusExtrapolation.ExtrapolatedPosition (optional)
  Position of the external encoder after extrapolation and hysteresis.
- <TO ExtEncoder>.StatusExtrapolation.ExtrapolatedVelocity (optional)
  Velocity of the external encoder after extrapolation and hysteresis.
- <TO SlaveAxis>.ActualPosition (optional)
  Actual position value of any synchronized axis coupled to the external encoder for checking the synchronized coupling and the quality of the set filtering.
- <TO SlaveAxis>.ActualVelocity (optional)
  Actual velocity value of any synchronized axis coupled to the external encoder for checking the synchronized coupling and the quality of the set filtering.

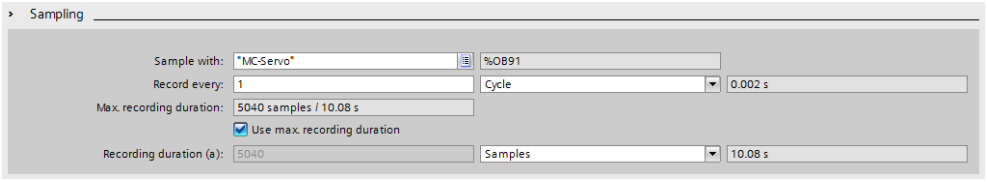
Figure 3-2 Trace configuration



In the "Recording conditions" under "Sampling" you select "MC Servo" for "Sample with" and if necessary, you configure a trigger condition in the trigger settings.

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Figure 3-3 Signal sampling

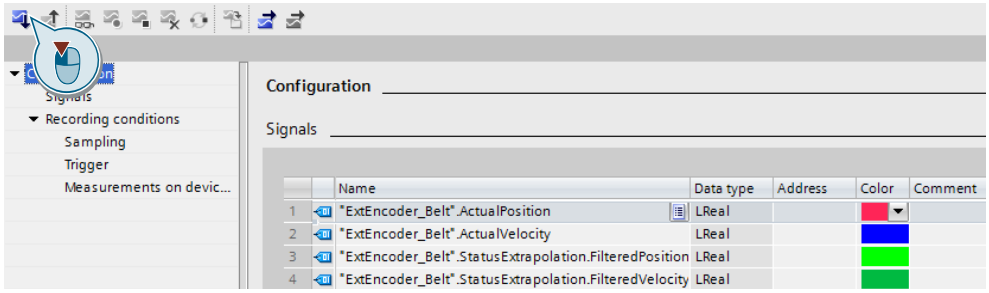


Note It is not absolutely necessary to define a trigger condition for the trace recording. The trace recording can also be started manually via the TIA Portal and then evaluated.

3.1.4 Loading the Trace into the Controller

Load the prepared trace into the controller.

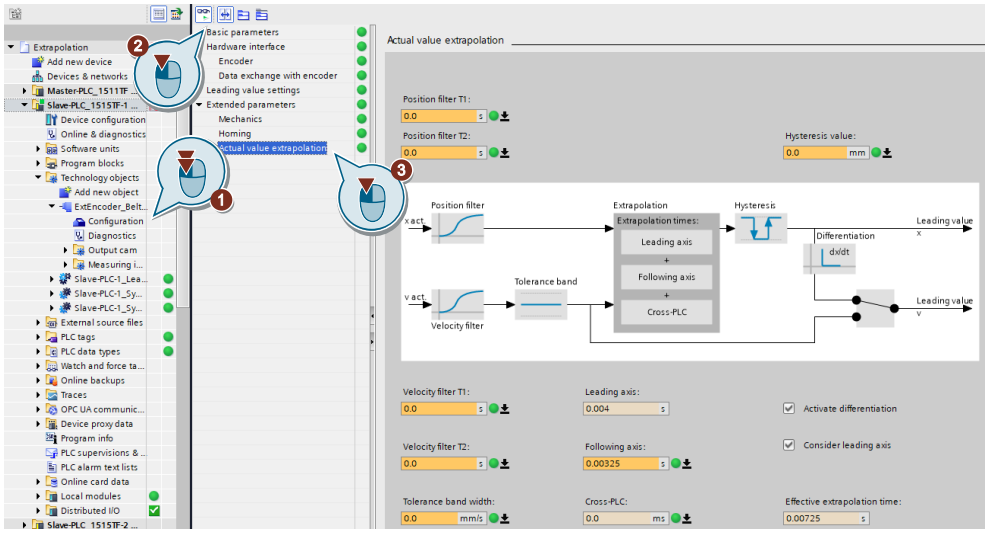
Figure 3-4 Loading the trace into the controller



3.1.5 Monitor actual value extrapolation parameters online

Connect the TIA Portal online with the controller and view the filter settings of the technology object "External encoder" in the Online mode.

Figure 3-5 Viewing filter settings online



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3.2 Determining Filter Settings Empirically

Note

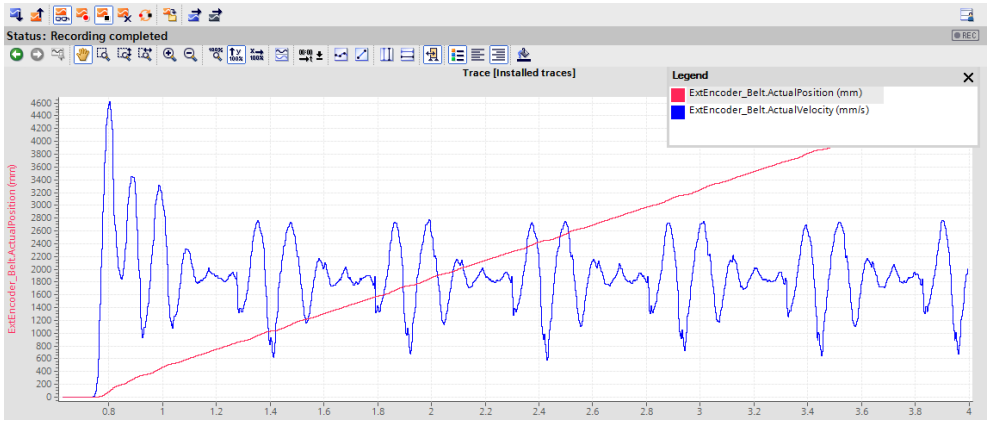
To better display the interaction of the individual filter parameters high disturbances were generated on the external encoder. The resulting fluctuations on the encoder and the following axis are an exaggerated representation of disturbances that do not normally occur in real operation. The figures should therefore only be viewed as examples.

In real operation the filters described here should only be used for high frequency disturbances.

3.2.1 Creating a Reference Trace Recording

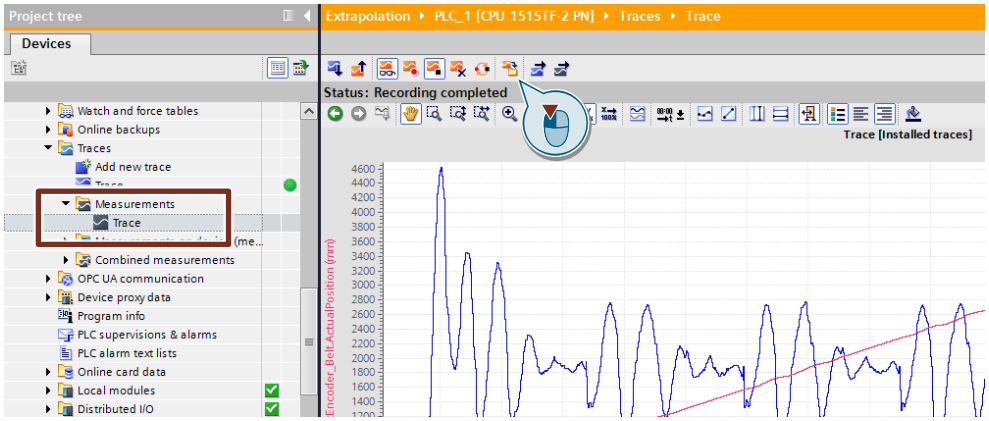
Start the machine or drive axis of the external encoder and first perform a reference trace recording of the technology object without filter settings.

Figure 3-6 Reference trace



Save the trace recording made as a reference in the measurements of the TIA Portal. The saved recording is then located in the subfolder "Measurements" under "Traces".

Figure 3-7 Saving the reference trace in the project

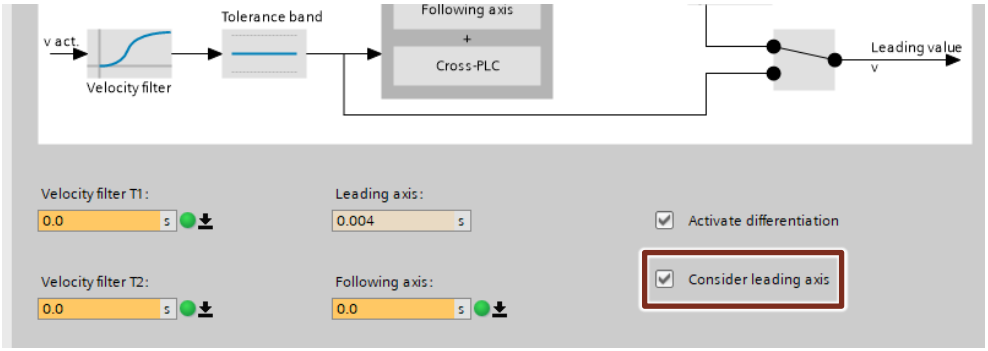


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3.2.2 Setting "Consider leading axis"

If the application does not require extrapolation the setting "Consider leading axis" should be disabled. Otherwise the leading axis dependent delay will be considered for extrapolation.

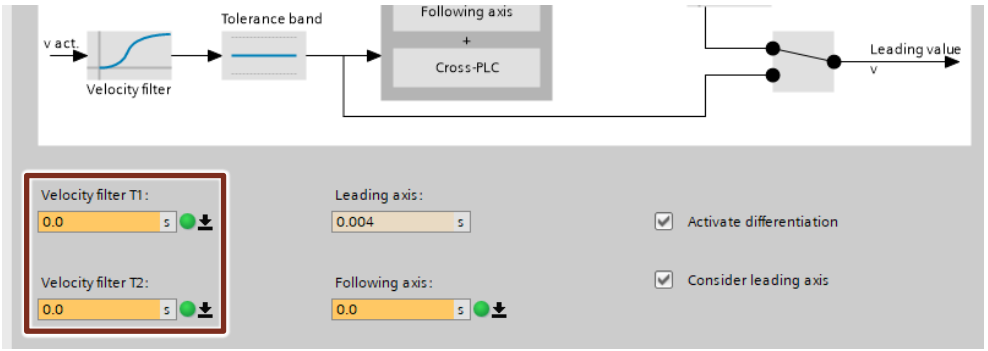
Figure 3-8 Setting "Consider leading axis"



3.2.3 Determining the Setting of the Velocity Filter

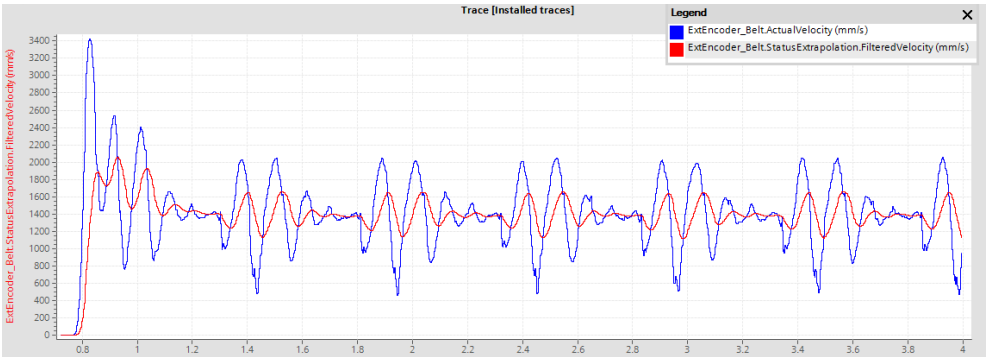
In the online mode for the technology object you set a small value (0.100s or 0.200s, for example) for the velocity filter.

Figure 3-9 Filter time constraints for the velocity filter



Start the machine or drive axis of the external encoder and perform a trace recording with the specified setting.

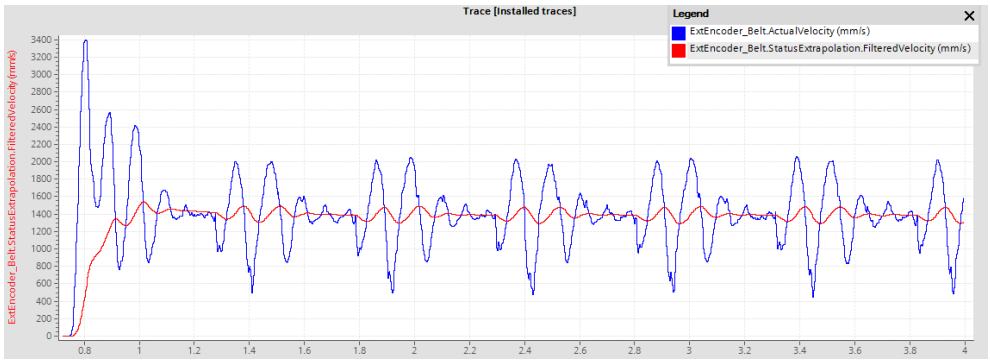
Figure 3-10 Trace with the specified settings



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If you do not obtain a significant or satisfactory smoothing of the velocity signal with the filter setting made, then, if possible, you should double the set filter value and do the measurement again.

Figure 3-11 Satisfying velocity filter



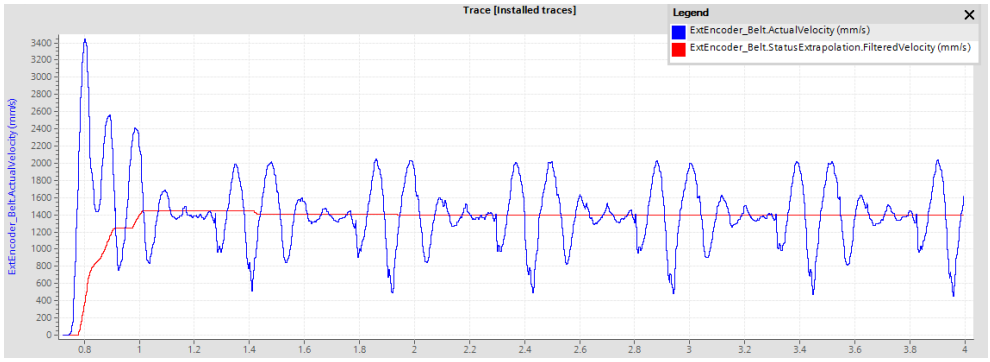
Note Each time a filter parameter is changed you should pay attention to the behavior of the following axis. Changes to the filter parameters are particularly noticeable in the actual velocity value derived from the actual position value.

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3.2.4 Determining the Setting of the Tolerance Band of the Actual Velocity Value (Optional)

Now any jumps or fluctuations still in the signal of the actual velocity value can be limited even further. For this you set the tolerance band as close as possible to the width of the remaining noise signal. How the tolerance band works is described in section 2.2.4.

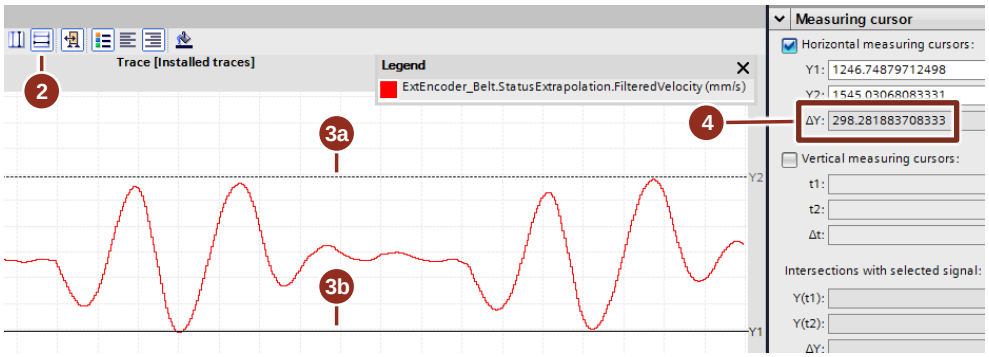
Figure 3-12 Appropriate tolerance band



Determine a suitable tolerance band value as follows:

1. In the trace you increase the signal <TO ExtEncoder>.StatusExtrapolation.FilteredVelocity until the fluctuations can be measured.
2. Activate the horizontal measuring cursor.
3. Place a horizontal measuring cursor each on a positive fluctuation and on a negative fluctuation.
4. Read off the velocity difference of the two measuring cursors and transfer this as tolerance band value paying attention to the units.

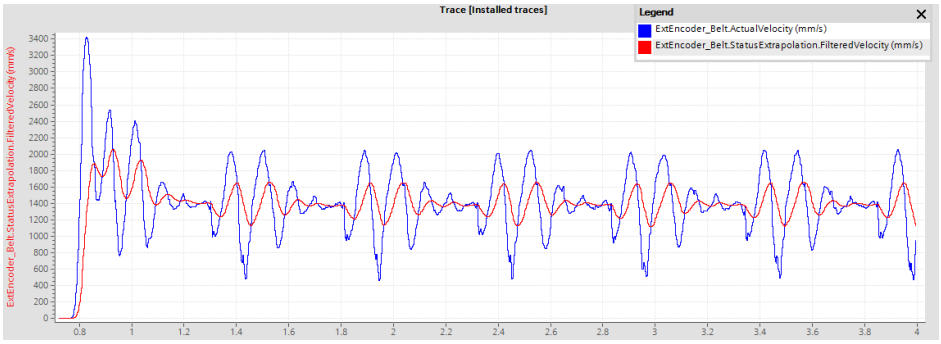
Figure 3-13 Determining the tolerance band value



Try to obtain the best possible setting of the tolerance band:

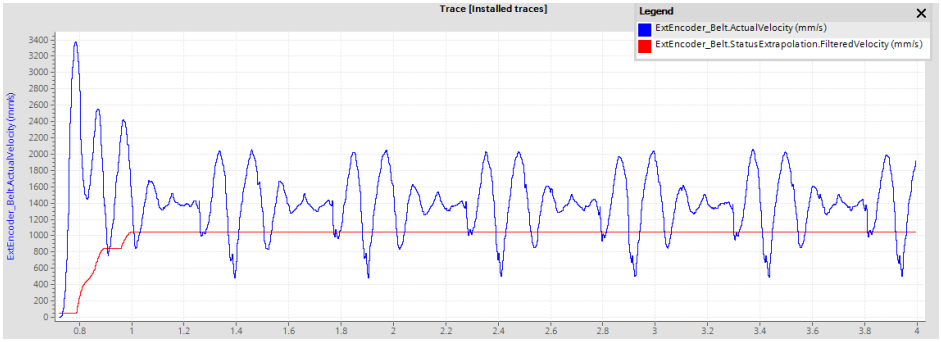
- If you select a too small value for the tolerance band, the signal of the actual velocity value is not smoothed adequately. The output signal continues to follow the fluctuations of the actual velocity value.

  Figure 3-14 Too small tolerance band value



- If you select a too great value for the tolerance band, the shift of the signal of the actual velocity value might be too big and the velocity profile falsified.

  Figure 3-15 Too great a tolerance band value



Now check whether other filter settings of the technology object are needed or whether the behavior of the machine is as you require:

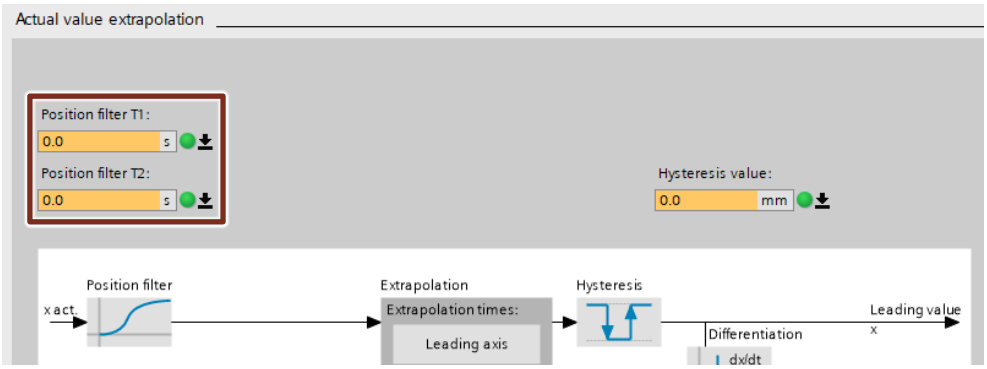
- If the machine and the connected axes behave as required, then continue as described in section 3.2.8.
- If the position value of the external encoder is also used in the application and it is still too noisy, then proceed with the setting of the position filter as described in section 3.2.5.

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3.2.5 Determining the Setting of the Position Filter (Optional)

In the online mode for the technology object you set a small value (0.200s, for example) for the position filter T1. Generally, the position filter T2 is not used.

Figure 3-16 Settings of the position filters T1 & T2

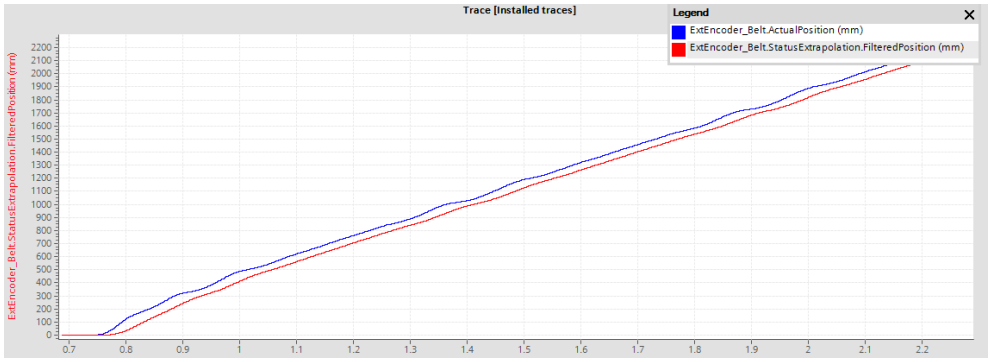


The filter time constants can be changed directly and, therefore, become effective directly, without restarting the TO, in the system-side extrapolation time <TO>.Extrapolation.LeadingAxisDependentTime.

As a rule of thumb, the position filter should be set 5 to 20 times smaller than the velocity filter. A typical value for the position filter would be, for example, 0.010 s.

Examine the filter effect of the setting made in the trace.

Figure 3-17 Appropriate position filter



Setting the position filter creates an offset between the actual position value and the filtered actual position value of the external encoder. If this offset can be tolerated, then continue with section 3.2.8 otherwise, the extrapolation time must be determined in the next step.

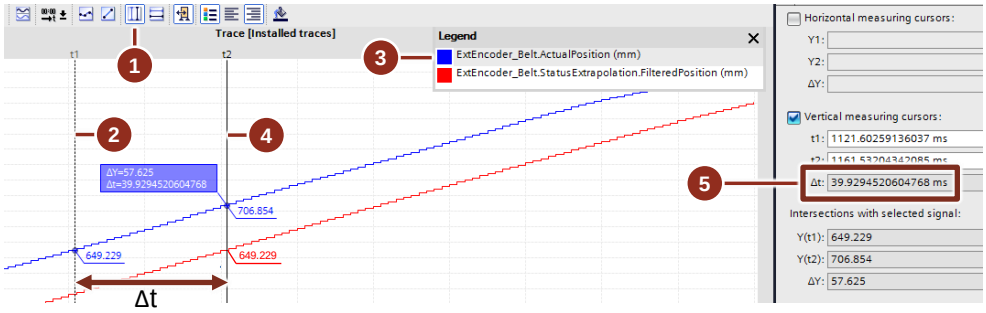
3.2.6 Determining the Settings of the Extrapolation (Optional)

The extrapolation time is automatically calculated by the system and saved in the variable <FollowingAxis>.StatusPositioning.SetpointExecutionTime as described in section 2.2.5. Apply the online value of this parameter as the extrapolation time.

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In case the result is not satisfactory now try to determine the delay of the filtered signal from the ratio of the position and velocity signals and set the delay time determined in this way as the extrapolation time.

Figure 3-18 Determining the extrapolation time

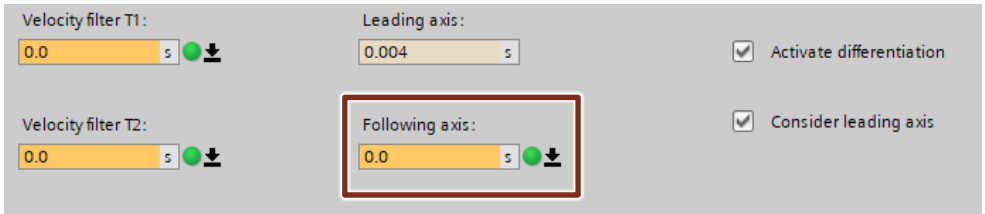


Proceed as follows:

1. Make sure the signals are scaled equally.
2. Activate the vertical measuring cursor.
3. Place a vertical measuring cursor at any place in the recording.
4. Now select the signal "ActualPosition" in the legend so that the measuring cursor shows the actual value of the position chosen.
5. Now select the corresponding filtered actual value of the signal "FilteredPosition" in the legend and place the second measuring cursor at the point in the recording at which it measures the same value as the first measuring cursor.
6. Read off the time difference of the two measuring cursors and transfer this value as extrapolation time paying attention to the time units. Theoretically the measured value should be the sum of the position filter times T1 & T2 and <FollowingAxis>.StatusPositioning.SetpointExecutionTime.

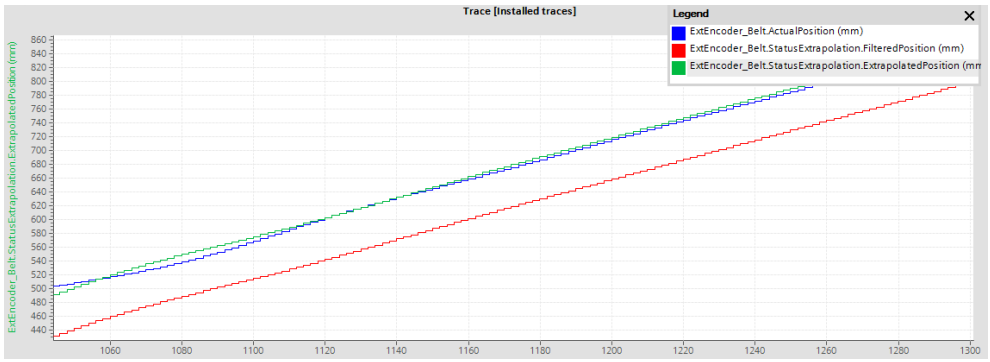
Note Note that the setting of an extrapolation can easily lead to a deterioration of the signals of the external encoder. It might be possible here to obtain a better coupling of a following axis without setting the extrapolation.

Figure 3-19 Setting the extrapolation time



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Figure 3-20 Satisfying extrapolation time

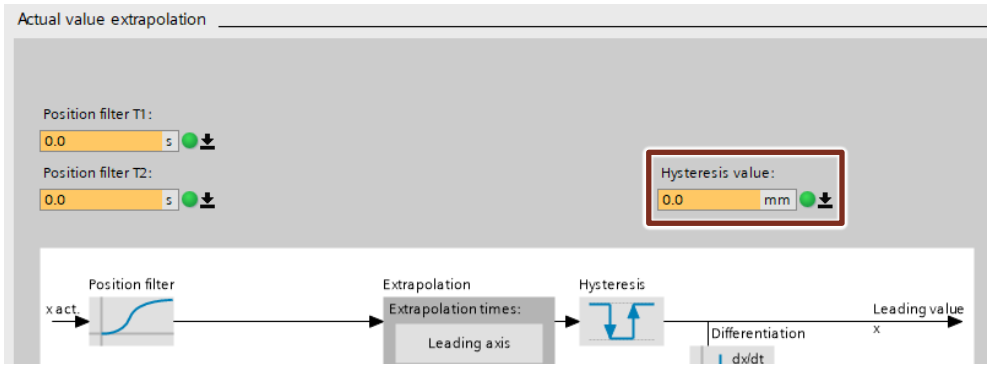


If the application requires a reversal tolerance to avoid errors when synchronizing to the leading value, then a hysteresis value has to be determined in the next step. If this is not necessary, proceed with section 3.2.8.

3.2.7 Determining the Settings of the Hysteresis (Optional)

It might be necessary to set a hysteresis if errors occur (e.g. MC-Alarm 608) during synchronization due to change of sign in the velocity leading value. Similar to the tolerance band described in section 3.2.4, you use the trace to determine the required reversal tolerance taking the extrapolated position value and enter this as the hysteresis value.

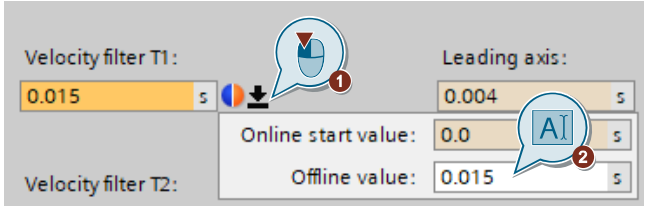
Figure 3-21 Determining Hysteresis



3.2.8 Applying Filter Settings

Apply the empirically determined filter settings and save the project.

Figure 3-22 Applying filter settings



Finally, reload the technology object onto the PLC to transfer the new project value online as the start value.

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4 Brief Instructions for Determining Parameters

The following table provides brief descriptions of all the steps for determining the filter settings. Detailed information on the individual steps is given in the relevant sections.

Table 4-1 Steps for determining the filter settings and extrapolation

No.	Action	Comment
1.	**Reset filter settings** (section 3.1.1) Reset all the filter settings of the external encoder and load the project into the CPU.	
2.	**Create reference trace** (section 3.2.1) Create a reference trace of the position value and velocity value of the external encoder without filter settings and of the actual values of the following axis if relevant.	
3.	**Setting "Consider leading axis"** (section 3.2.2) If the application does not require extrapolation the setting "Consider leading axis" should be disabled.	Otherwise the leading axis dependent delay will be considered for extrapolation.
4.	**Determine velocity parameters** (section 3.2.3) Select a value for the velocity filter until the velocity profile on the parameter <TO ExtEncoder>.StatusExtrapolation.FilteredVelocity provides satisfying smoothing.	Start with a small value like 0.100s or 0.200s, for instance.
5.	**Determine tolerance band of actual velocity value** (section 3.2.4) Use the trace to measure the fluctuations to be filtered in the filtered velocity <TO ExtEncoder>.StatusExtrapolation.FilteredVelocity and apply this as tolerance band value.	The tolerance band should be chosen so that, for example, fluctuations at constant velocity are filtered, but also so that the velocity profile is not falsified.
6.	**Determine position filter values** (Section 3.2.5) If the position profile also has to be smoothed, this can be done with the position filters T1 and T2. The parameterization of the position leads directly to a shift of the setpoint position of the following axis. This shift can be eliminated in the next step.	As a rule-of-thumb formula you should set the position filter to be less than the velocity filter by a factor of 5 to 20.
7.	**Determine extrapolation time** (Section 3.2.6) Use the trace to determine the shift of the actual values and the filtered actual values of the external encoder. This time shift can be entered as extrapolation time.	The extrapolation can lead to deterioration of the following axis. Check whether you can reduce the position filter instead. Otherwise you also parameterize a hysteresis value as needed.
8.	**Determine hysteresis value** (Section 3.2.7) If further fluctuations of the velocity or position of the following axis occur, they can be filtered with the hysteresis. For this you use the trace to measure any interference signals or vibrations that also have to be filtered.	During standstill, fluctuations might arise on the encoder through external influences and have a great influence on the following axis. You can measure these fluctuations, for example, via the actual velocity value of the external encoder.
9.	**Apply the filter values** (Section 3.2.8) Then compare the result of the actual value extrapolation with the reference trace made in Step 1. Then transfer the filter settings to the project.	

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